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## Synchronization of the G Giant Rotation in the Symbiotic Binary StH $\alpha$ 190?

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**Abstract.** We present an analysis of high resolution spectral observations of the symbiotic star StH $\alpha$  190. A 30 days period has been derived from radial velocities of the *G-type* absorption lines and the HeII  $\lambda 4686\text{\AA}$  emission line. The main aim of this work was to look for explanation of the very wide absorption lines of the yellow giant. The very low mass function obtained from the absorption lines radial velocities suggests that the observed changes probably do not correspond to the orbital motion of this star.

### 1. Background, observations and methods

StH $\alpha$  190 was discovered by Stephenson (1986), during an objective-prism survey for emission-lines objects. Now it is classified as a *yellow d'* symbiotic star. The system consist with a rapidly rotating (Figure 1)  $v_{rot} = 105\text{ km s}^{-1}$  (Munari et al. 2001) *G2 III/IV* star (Smith et al. 2001), and a moderate temperature  $T_h \sim 50000$  white dwarf (Schmid & Nussbaumer 1993).

An inspection of the catalogue of rotational velocities (de Medeiros et al. 1999) shows that almost all G stars rotate with  $v_{rot} < 10\text{ km s}^{-1}$ , and only eleven of listed stars have  $v_{rot} > 20\text{ km s}^{-1}$ . Most of these relatively fast rotating stars are recognized as peculiar or "single-lined" spectroscopic binaries.

Periodic changes of about 900 days and an amplitude 0.16 mag, were discovered in *K-band* photometry by Whitelock et al. (1995). They speculated that this is system orbital period. Munari et al. (2001) suggest a possible 171 days spectroscopic period of StH $\alpha$  190, based on *NaD* radial velocities. Smith et al. (2001) showed that a shorter 37-39 days period is more possible.

We have used 30 high resolution spectra with resolving power  $16000 < R < 54000$  obtained during four years. The spectra have been processed in a

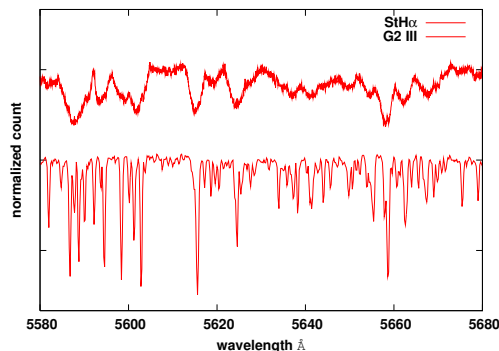


Figure 1. Apart of the optical spectrum of StHα 190 the spectrum of the standard star *G2 III* (*HD126868*) from *OHP* ELLODIE library is plotted for comparison.

standard IRAF way. To measure the radial velocities of emission lines, we used the IRAF's RV package. For the absorption lines radial velocity measurements the cross-correlation method has been used. As a reference standard spectrum we chose a G2 III one from the synthetic spectra library Zwitter et al. (2004), on basis on the parameters obtained by Smith et al. (2001).

The Fast Fourier Transform (FFT) for unequally spaced data was computed for a periodicity analysis. The simply Deeming (1975) method has been used. Using the mean square method, the simple sinus function has been fitted to phased data.

## 2. The spectroscopic period

Figure 2 shows the radial velocities *FFT* of the *G-type* star absorption lines and the HeII  $\lambda 4686\text{\AA}$  emission line, as well as the phased data. The detailed analysis of the periodograms showed that the main period of changes observed in radial velocity is 30.5 days in both cases. The HeII  $\lambda 4686\text{\AA}$  emission line was presented only in eleven spectra during the four years observing period. The spectral windows of the Fourier transforms obtained from the radial velocities of the *G2* star absorption lines, and the HeII  $\lambda 4686\text{\AA}$  emission line are very different. The fit details are listed in Table 1.

Table 1. Summary of radial velocity changes. 'P' is the orbital period, 'K' is the semi-amplitude,  $\gamma$  - radial velocity of mass center, and  $T_0$  - moment of conjunction.

	$P$ [d]	$K$ [km s <sup>-1</sup> ]	$\gamma$ [km s <sup>-1</sup> ]	$T_0$ [HJD]
Absorptions	30.488	5.238	10.876	2451564.922
HeII $\lambda 4686\text{\AA}$	30.497	20.035	0.790	2451564.189

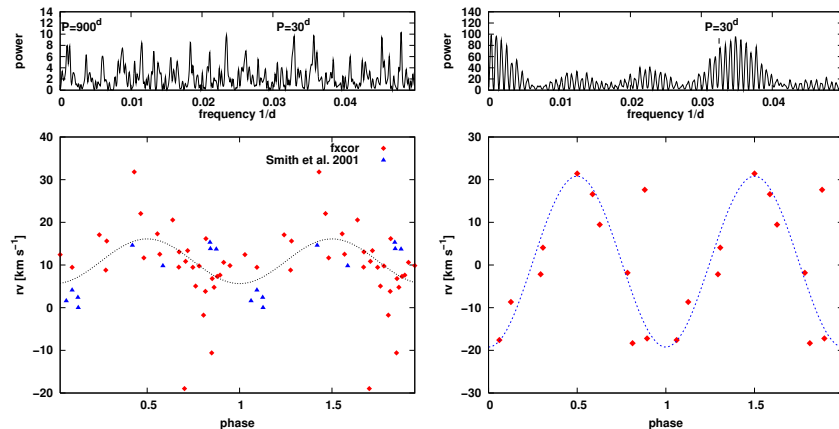


Figure 2. Upper row presents the FFT of radial velocities of *G2* star absorption lines (left) and HeII  $\lambda 4686\text{\AA}$  emission line (right). Lower row shows phased radial velocities of mentioned lines with period  $P = 30.^d488$  and  $P = 30.^d497$  respectively for cool star absorption lines and HeII  $\lambda 4686\text{\AA}$  emission lines. The moments of conjunction ( $\phi = 0.25$ ) are almost the same. The radial velocities of mass centres differ of about  $10 \text{ km s}^{-1}$ .

### 3. Spectral Energy Distribution

Following Skopal (2007) we have calculated the spectral energy distribution (see Figure 3). The model includes: the hot and the cool stars, the gaseous nebula, and the dust radiations. We have completed the model of the hot gas radiation with a two photon radiation ( $2\gamma$ ), which could be a significant source of the observed ultraviolet flux. The model of *G2 III* star was taken from  $1\text{\AA}/\text{pix}$  spectral library of Munari et al. (2005). The infrared radiation is fitted with three black bodies.

### 4. Summary

The spectral energy distribution (Figure 3) confirms the presence of a *G2 III* star in the system. We have obtained  $R \sim 10R_{\odot}$  and  $L \sim 63L_{\odot}$ , in agreement with the values  $R \sim 8R_{\odot}$  and  $L \sim 50L_{\odot}$  reported by Smith et al. (2001).

Using the period of 30.5 days and the semi-amplitude of the radial velocity changes of about  $5.2 \text{ km s}^{-1}$  we obtained a mass function  $f(m) = 0.0005 M_{\odot}$ . Such low mass function indicates very high mass ratio of about  $q \geq 15$ . Using for the cool star a mass  $2.5M_{\odot}$  we can estimate lower value for mass of the invisible companion as  $M_h \sin i \leq 0.15M_{\odot}$ . Such mass of the hot companion is unrealistic which suggest that radial velocities variations do not reflect the orbital motion. This means that 30 days period is not orbital one and that we cannot consider the synchronous rotation of the yellow giant as an explanation of the very wide absorption lines in its spectrum.

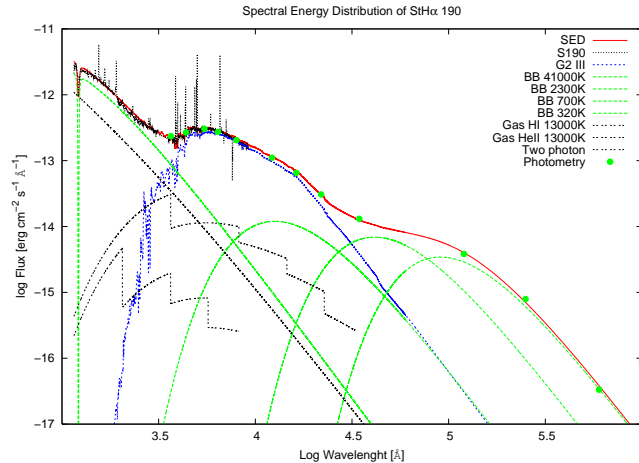


Figure 3. Spectral energy distribution of StH $\alpha$  190 from UV to IRAS 120 $\mu m$  band.

A more detailed analyses of the absorption lines in the observed in optical spectrum of StH $\alpha$  190 are needed to solve the problem with observed high rotation of the yellow giant.

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